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DOMESTIC AND MUNICIPAL WATERWORKS IN ANCIENT MEDITERRANEAN LANDS

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THE long summer drought made the presence of water a controlling factor in the distribution of population in the ancient Mediterranean lands. It determined both the size and location of the rural community, wherever irrigation made a drain on the local water. The scarcity of unfailing streams emphasized the importance of perennial springs or wells. Where these were numerous the villages were generally numerous and small; population broke up into small groups, with their farm lands conveniently near. But where the springs were sparsely scattered, population had to concentrate about them in fewer groups, no matter how long might be the way from home village to outlying fields.

Importance in the Region at Large

The growth of large and populous cities became possible only after the development of a complete technique of waterworks, which utilized water from local sources and also introduced it from distant springs, rivers, or lakes. The construction of such works depended also upon the concentration of urban wealth. Impressive waterworks appeared first in ancient seaports with profitable maritime commerce like Samos, Cnossus, Athens, and Megara; or ancient capitals like Jerusalem, Corinth, Carthage, and Rome; or active local markets like valley towns of the Apennines or the Atlas Mountains. This waterworks construction was stimulated by the requirements of municipal and private baths, made almost imperative for health and comfort in the hot, dry summers. Moreover, the ancients recognized the connection between water famine and pestilence. Virgil vividly describes their operation in Crete.

All ancient literatures reflect the concern of the Mediterranean people to secure a pure and ample domestic water supply. Aristotle says: "There should be a natural abundance of springs and fountains in the town; or, lacking these, large reservoirs may be established for the collection of rain water, such as will not fail when the inhabitants are cut off from the country by war . . . if the water supply is not all equally good, the drinking water ought to be separated from that used for other purposes."

To protect the water against pollution and theft heavy punishments and fines were imposed in Greece and Italy. Furthermore, the Roman plutocrats had their drinking water first boiled and then chilled by mountain snows; if the snow was not clean, it was strained through fine linen cloths. In this they imitated the practice of Cyrus the Persian who on his campaigns took his drinking water with him from Susa, boiled and carried in silver vessels.

As to the sources of drinking water, all authorities commend spring water and rain water conducted to a reservoir in earthenware pipes, as opposed to water from muddy streams or stagnant pools and marshes. Columella gave a second place to mountain streams tumbling over rocks. He agrees with Hippocrates the great physician, who preferred water "flowing from high ground and hills, sweet and clear" and water derived from deep wells.

From Palestine to Spain the "fountain of living water" was the great desideratum. The spring was the nucleus of town and village life, the starting point around which the community grew up, like the Virgin's Spring in Nazareth. In Greece also, to the mind of the native, it became identified with his home town. When Theognis of Megara (d. about 540 B. C.), disgusted because a political upheaval dislodged the oligarchs and placed the common people in power, decided to become a voluntary exile, he expressed his purpose in terms of his native spring:

> The years I dropped my pitcher in the clear dark village spring
> How sweet and good the water's taste did seem.
> But now the rains have flooded it, the mountain streams have muddied it,
> I'll drink another spring, a larger stream.

About the village spring or its reservoir the women gathered in the twilight, water jars on their shoulders, as they may be seen today in Nazareth or some hamlet in the Apennines, to linger and gossip. Here at all hours the men resorted to discuss local affairs and advertise matter of local concern. The importance of the town spring or pool is reflected in the care Pausanias takes to mention its name, its site, its mountain or piedmont source; and, if its water has been brought from a distance, he tells who installed the conduit. He does this for all the ancient Hellenic world from Antioch and Asia Minor to Syracuse with its Fountain of Arethusa. He includes even a village like Pyrrhichus near Cape Malea, whose sole water supply was provided by a conduit built by the demigod Silenus from a distant spring to the market place. Many of the springs have a mythological or miraculous origin, like the Dirce Spring of Thebes; or the conduit from mountain to city is attributed to the legendary founder of the colony, like the aqueduct to the Theban Cadmeia from the Cithaeron Mountains. In any event it is identified with the

beginning of the city. The Fountain of Priene, the famous spring of Corinth, shows five building periods in its well house, which dates from the sixth century B. C.

West of the Jordan

Conditions in Palestine and Syria favored an individual rather than a community water supply. "Drink waters out of thine own cistern, and running waters out of thine own well," says the Hebrew proverb. Better still was a spring, or "fountain of living water," for cisterns hewn from the limestone rock might leak through natural clefts. Often the spring in the limestone country was underground, reached by a well shaft; where the flow was very abundant, such a spring or well was sure to have a whole village or town grow up about it. Such is the Virgin's Spring of Nazareth, sole water supply of the town today as in the boyhood of Christ. The numerous place names in Palestine beginning with *En* or *Ain*, meaning spring, point to the water supply as the determining factor in locating a town or village.

The coastal plain of Palestine and Syria was supplied by the "fountainheads," or springs, that burst forth near the base of the Judean and Lebanon highlands; and also by wells sunk to the ground water. In the Philistine plain the ground water rose near the surface and supplied the ample wells of Gaza and Ashdod; but on the steep coast of Lebanon where the ground water has a rapid run-off, the ancient Phoenicians probably placed their chief reliance upon mountain streams and springs. The authorities give meager material on this point, though the Phoenicians were famous throughout the Mediterranean region as hydraulic engineers. Only Strabo reports the ingenuity of the island city of Aradus in achieving a water supply. Rain water from the roofs was stored in cisterns; and in addition a submarine spring, which welled up in the sea a few hundred yards from the port, was tapped by sinking over it a great inverted funnel with a hose attached.

Springs are copious and numerous along the western escarpment of the Judean Plateau but shrink rapidly in size and number in the rain shadow to the east. The pastoral region of the Negeb to the south has always been a transition belt physically and climatically between the Judean Plateau with its moderate winter rains and the Desert of Paran. The few springs and wells of the Negeb were essential for field or herd. Even Debir, near the northern margin of Hebron, was scarcely habitable without springs. Isaac, who occupied the southern district, kept close to the well of Lahai-roi. Wells sunk in the dry wadi beds were private possessions fought over by the rival herdsmen of Abraham and the neighboring king of Gerar. The

Philistine sheik filled up the wells, using an ancient method of maintaining a waste boundary to exclude encroachments of neighboring nomads. It was employed also as a punitive measure by the kings of Judah and Israel when they invaded the Moabite country east of the Dead Sea.

The cities of Palestine, with their concentrated populations, felt the need of exploiting all local resources to assure their water supply. As walled towns, subjected to siege in a warlike age, they were peculiarly dependent upon the water supply of summer, because campaigns were generally made in this season. While each house had a cistern to store the rain water from its own roof, the city provided public pools or reservoirs formed by damming a valley stream; in many cases these were supplemented by aqueducts from distant springs. Pools acted as settling tanks and were often connected with public baths. In this case they were surrounded by porticos where the bathers rested or lounged, protected from the sun. The Pool of Siloam at Jerusalem had four such porticos, whose remains have been excavated, and the Pool of Bethesda had five, one of them running across the middle of the basin and dividing it into two parts. Besides Siloam and Bethesda, Jerusalem had its Upper Pool, its Lower Pool, the King's Pool, Old Pool, and Hezekiah's Pool. Josephus mentions also four others existing in the city at the time of the Roman conquest. The Pools of Solomon, three large reservoirs ranging from one to two acres in area, may be seen today beyond Bethlehem eight miles from the ancient capital. They are possibly the "pools of water" made by Solomon to irrigate the gardens and orchards of his summer palace; but their water was conveyed to Jerusalem by a very ancient conduit, over thirteen miles long, which tunnels the hill of Bethlehem. The Pool of Siloam was fed in part by a tunnel conduit which brought water from the Fountain of the Virgin and which, from an inscription on it in Phoenician characters, must date from the eighth century before the Christian era or even earlier. King Hezekiah dammed the upper watercourse of Gihon and brought the water by conduit to his Pool in the west side of the city of David. The channels were largely hewn in the rock and were always covered with stone slabs to keep the water pure and reduce evaporation.

Other towns also had their pools, like Gibeon, located ten miles northwest of Jerusalem and famous for its "high place" where Solomon worshipped; Hebron, near the summit of the Judean Plateau where two ancient reservoirs survive, one 132 feet square. On the arid eastern escarpment of the Judean Plateau, tanks and aqueducts fed by limestone springs supplied water to cities like Jericho and Bethshan. Herod built reservoirs on a large scale to impound the local spring water in the citadel of Macherus, a natural fortress on a high headland overlooking the Dead Sea; and he also built rock-hewn cisterns in

Masada, as Josephus has described, when he began to fortify the frontiers of his kingdom.

On the Desert's Edge

Across Jordan, on the westward-facing escarpment of the plateau of Arabia, poverty of water necessitated its early conservation wherever towns grew up along the ancient highway from the Red Sea north to Damascus and the great bend of the Euphrates. The Moabite capital of Heshbon, an important place when Moses traveled towards Canaan, had a pool fed by springs or streams from Mt. Pisgah and famous for its beauty. The ruins of a tank at Heshbon show it to have been 191 feet long, 139 feet broad, and 10 feet deep. Mesha, King of the Moabites in the time of Jehoshaphat, according to the famous Moabite Stone built reservoirs for Baalmeon and other cities of this plateau. Madeba, which existed in Mesha's time, now shows the ruins of a pool which measures nearly three acres.

Owing to the incursions of desert tribes on the western edge of the Syrian Desert, extensive water works had to wait for the rule of the Romans and were therefore chiefly of Roman construction; but in some instances the Roman and earlier native works lay side by side. Petra is an example. Known to the ancient Hebrews as Sela, or the Rock, it was the capital of Edom when that country was conquered by King Amaziah of Judea; but it began to attain importance as a desert market under the Nabateans about 100 B. C. and reached preëminence only after the Roman conquest. Located on an arid plateau 3000 feet high, south of the Dead Sea, it depended on ancient aqueducts from springs two miles up the Wadi Musa Valley above the town. The earliest conduits were cut in the soft sandstone of the wadi walls, far above the stream; but the later Roman aqueducts of clay pipe were let into the opposite face of the cliff and secured by cement. The "high places" also about the city were provided with small rock-hewn pools which doubtless figured in the primitive ceremonies to rain-giving Baal. An extensive system of channels and small tanks for gathering the rain water equipped the long canyon approach to one of these "high places" for the benefit of thirsty pilgrims in the dry season. These undoubtedly belonged to the earliest period of the city's life. Strabo tells us that in his time Petra derived from its springs enough water for domestic use and for the city gardens but that the country about was for the most part desert. These conditions point to careful exploitation of the local water supply.

Despite these provisions for a regular water supply, there were times when successive years of diminished rainfall encroached upon the narrow margin of moisture; when men scoured the country for

the last surviving trickle from some hidden spring; and when the hart indeed panted after the water brooks, which had become beds of gravel. Then Isaiah's promise to the righteous man, "Bread shall be given him; his waters shall be sure," guaranteed something more than the commonplace. The Hebrew proverb "Stolen waters are sweet" testifies to the fierce thirst that prompted the petty theft rather than to a fictitious zest lent by an unlawful act. The scriptures abound in instances of water miraculously supplied, generally in the "wilderness" or desert borders but occasionally also on the Judean Plateau and even on the wooded slopes of Mt. Carmel.

All the region on the fringe of the Syrian Desert, from Palmyra to Petra, offered sites for settlement only where oasis conditions existed; where rare perennial streams like the Jabbok, Yarmuk, and "the rivers of Damascus" offered an unfailing though variable water supply; or where water from distant wadi or springs could be brought by aqueduct or underground conduit to reservoirs in the town. The copious streams that flowed from the Anti-Lebanon range and Hermon to the oasis of Damascus guaranteed that city a natural water supply. Elsewhere the human task was vastly greater, and the accomplished work more easily jeopardized. Palmyra is described by Pliny as located "in a region that all around in a vast circle is a sand desert and separated by nature from other lands" yet famous for its fertile soil and pleasant water brought in covered aqueducts and stored in reservoirs. Palmyra, first mentioned in 41 B. C. and flourishing in the imperial period of Rome, owed the security of its water works to the partial protection of the Romans, whose trade the city forwarded to the Euphrates.

The remains of all the highland cities of eastern Syria show the ruins of Roman aqueducts, baths, reservoirs, and occasionally a *naumachia*, or naval pool, like that at Gerasa. Gadara, which lay on the route from Esdraelon to Canatha and the Hauran, occupied an admirable fortress site on an important highway but had to depend on cisterns and a meager spring till the Romans built it a thirty-mile aqueduct. Their engineers also exploited the streams of the Hauran Mountains, whose great massif, 6032 feet high, condensed abundant winter rains and supplied water to Canatha, Bostra, Philippopolis, and the three hundred villages skirting the slopes.

Other towns of Gilead and Bashan whose history extends back to legendary days relied on cisterns, rock-hewn reservoirs, and wells, whose remains can be seen today amid the later remains of Roman baths and aqueducts. The ancient capital, Rabbath Ammon, rebuilt by Ptolemy Philadelphus and later improved by the Romans, depended during the siege of the city by Antiochus (218 B. C.) upon an underground passage giving access to one of the many deep reservoirs that were utilized by the natives in periods of danger.

Hellenic Concern over Water Supply

The Hellenic cities show equal concern for their water supply and a high regard for springs, to which they often attributed great sanctity or a miraculous origin, probably as a method of social control to protect the water supply against pollution. Many of them sacred to Apollo and Demeter, divinities of agriculture, suggest the utilization of their waters for irrigation. Others issued from sacred groves, which probably owed their sanctity as well as their trees to the god-given waters. Others rising in caves made the grottos holy places, shrines of gods or abodes of nymphs. In the summer droughts the undiscouraged flow of some rocky fountain must have seemed to the thirsty a perennial miracle. One hears the wayfarer exclaim with Pindar, "Water is best of all." In modern Greece the good-by wish to the departing guest is: "A safe journey and fresh water."

Springs, of paramount importance to the ancient Greek cities, provided the first local water supply. City springs meet us in Homer, in the fountain of Hyperia in Pegasae on the Gulf of Volo, by the roadside in the city of Alcinous, and in the Fountain of Arethusa in the capital of Ithaca. The last became famous; its name reappeared in the city spring of Euboean Chalcis and also in Syracuse. The Greek tyrants justified their beneficent despotisms by improving the water supply of their respective capitals. Pisistratus (605? to 527 B. C.) adorned the chief spring of Athens with a hall of columns where the water issued from nine jets, giving it the name of Enneacrunus, or fount of nine mouths. Water was brought for it by two conduits from the upper course of the River Ilissus, one of them passing underground out to the Piraeus. Other aqueducts, one from Mt. Hymettus and two from Lycabettus, contributed to the water supply of Athens, while a system of canals from the Cephissus irrigated the neighboring olive groves and gardens. The Greek conduits were generally subterranean channels cut in the natural rock. To keep them safe and clean, shafts were sunk at intervals, admitting light and air. At the entrance to Athens the aqueducts discharged their water into rock basins for settling before distribution through the city. When necessary, conduits pierced the hills by means of tunnels, as in Palestine.

Megara had its waterworks in the form of a long canal, built by the tyrant Theagenes in 620 B. C., which brought water from the mountains to a beautiful basin in the market place, famous for its size and decorations. Polycrates of Samos, about 530 B. C., employed the leading hydraulic engineer of his time, a native of Megara, to supply Samos city with water. The need was crucial for a big town on a small island, which, however, had a high mountain core. The task was accomplished by piercing the mountain by a tunnel nearly

a mile long to reach the springs of Mt. Ampelus. Thence water was distributed to the wells, pipes, and baths of the city, while the surplus went to cleanse the sewers. Corinth had the most famous city fountain of all Greece. The upper spring, located in its high rock citadel, was said to be the gift of the river god Asopus. So precious a boon on that bare rock could be explained only by a divine origin. The lower Priene spring has an elaborate well house. The colonnade over the basin and the bronze lion heads from which the water flowed are still to be seen.

More elaborate even than anything that democratic Greece could show were the waterworks and drainage system in the royal palaces of Crete, a thousand years before the time of the Greek tyrants. The palace of Cnossus had lavatories and sinks equipped with terra cotta pipes and drains of stone or cement. That of Phaestos had bathrooms well constructed and amply equipped. The water was probably brought in artificial channels from the high mountain range that forms the backbone of the island. These works antedated the Hellenic invasion of Greece and may have furnished the models for the later water systems. The widespread development of hydraulic engineering, however, must have been due to the need of irrigation as well as that of a reliable domestic water supply. The finest Greek aqueducts were the underground conduits of Syracuse, which brought drinking water to the city. These were destroyed by the besieging Athenian forces in 413 B. C. But Syracuse was not the only city so supplied. The victor of the Olympic Games in 452 B. C., returning to his native Camarina in Sicily, praises "the River Oanis and the lake of his native land, and the sacred channels wherethrough doth Hipparis give waters to the people."

Roman Developments

The Greek colonies located about the Bay of Naples may have given the first impulse to the utilization of the hot springs there for public baths and the consequent installation of the waterworks that supplied these baths and the fountains and fishponds in the private gardens of Herculaneum, Pompeii, and Cumae. But the city of Rome, heir to the hydraulic science of the Mediterranean Basin and desirous of providing water for its large population, shows the most extensive waterworks. The report of Sextus Julius Frontinus, water commissioner of Rome in 97 A. D., gives a complete survey of its system. The nine Roman aqueducts were carried mostly underground for safety in time of war. They crossed valleys on high arches. The Appian aqueduct, brought to the city in 313 B. C., was more than ten miles long and had its intake at a spring on the estate of Lucullus. The Marcian was sixty miles long and had its source in the Sabine

Mountains "where countless springs gush forth from caves in the rocks." Such springs were sought out, opened up to get an ampler flow of water, and then walled in with concrete to keep the source intact. The old Anio aqueduct, built in 273 B. C., came from the Anio River above Tibur, forty miles distant. Its water was often muddy during the winter rains, as was that of the New Anio conduit till a settling tank was built.

Rigid distinction was made between pure and impure water by the Roman water commissioner. The supply from the Alsietina duct was drawn from a lake, none too clean; hence it was not distributed to the public but was reserved for the Naumachia, the naval lake of the Caesars, or for irrigating gardens. The spring-fed aqueducts were considered the best, and these were reserved for drinking water. The water system of Rome supplied private houses, the 39 ornamental fountains of the city, and 75 public structures, chiefly baths, like those of Nero and of Caracalla. Gardens in and about the city also were supplied with water.

Fraudulent tapping of the public aqueducts and reservoirs was rife from early times. Illicit pipes were laid by the thieves, and the robbery was connived at by the watermen. Landed proprietors having estates along the course of the aqueducts tapped them to water their gardens. Frontinus, when appointed commissioner, made a survey of the city's water supply and rounded up the delinquents.

The attribution of curative power to various pools and fountains and even rivers permeates ancient Mediterranean life. The healing power of hot springs was recognized and exaggerated in Italy, especially in the volcanic regions, where the baths of Baiae and Naples became famous.

Commensurate with the importance of springs under Mediterranean climatic conditions and their large number wherever limestone predominated, an elaborate fountain architecture developed which set the standard for later times. This was especially varied and beautiful in the gardens and peristyles. It was stimulated also by the custom of erecting a nymphaeum, or temple, above the spring where it issued from the mountain source.

Finally, Rome instituted the Fontinalia, a religious festival in which garlands were thrown into all the city fountains of Italy and the god Fons appeared with the goddess Flora to secure abundant water.